REMARKS

Claims 1-9, all the claims pending in the application, stand rejected. Claims 1, 3, 4, 6 and 8 are cancelled. Claims 2, 5, 7 and 9 are amended.

Drawings

The Examiner indicates that the drawings filed with the application are objectionable because Fig. 13 should be designated by a legend "Prior Art". Applicant is submitting a revised figure with the appropriate notation.

Claim Rejections - 35 U.S.C. § 102

Claims 1-4 and 6 are rejected under 35 U.S.C. § 102(b) as being anticipated by Lu (1994). This rejection is traversed for at least the following reasons.

As a preliminary matter, Applicant has assumed that the Examiner's reference to Lu (1994) is specifically directed to the publication cited by the Applicant in an Information Disclosure Statement, that document entitled "A Study of Two-Dimensional Array Transducers for a Limited Defraction Beam." If this is not correct, the Examiner is requested to advise the Applicant as soon as possible.

With regard to claims 1, 3, 4 and 6, the rejection is moot in view of the cancellation of these claims.

With regard to claim 2, the claim has been placed into independent form, by incorporating the limitations from claim 1 therein and by adding the additional limitation that the transmission of a plurality of ultrasonic beams occurs substantially simultaneously. Applicants respectfully submit that, on the basis of this amendment, the combination of features recited in the claim makes it patentable over Lu.

With reference to Fig. 1 as a non-limiting exemplary embodiment that incorporates the present invention, Applicant notes that the Figure discloses an ultrasonic transmitting and receiving apparatus that comprises an ultrasonic transducer array 10 having transducers arranged in matrix form. The apparatus also includes a wave form information setting means 13 that sets wave form information to be used for transmitting a plurality of ultrasonic beams, each of which

is synthesized by a plurality of ultrasonic signals. The signals have amplitude and phase characteristics represented by Bessel functions. Finally, the apparatus includes a drive signal generating means 16, as disclosed at page 15-16, for generating a plurality of drive signals. The drive signals respectively drive the plurality of ultrasonic transducers on the basis of the waveform information set by means 13. The plurality of ultrasonic beams are transmitted within a predetermined period, so that the plurality of ultrasonic beams are transmitted substantially simultaneously. The beams are generated by respective sub-arrays, that may be overlapping or concentric as shown in Figs. 4 and 12.

Claim 2 recites the combination of the array, waveform information setting means and drive signal generating means, and further specifies that that the plurality of ultrasonic beams are transmitted within a predetermined period, so that they are transmitted substantially simultaneously. In this manner, the claim defines a multidirectional transmission and reception technique, using the sub-arrays, that is not found in the prior art.

Lu Publication

The Examiner cites the Lu publication for its teaching of the use of limited defraction beams, which have a finite aperture and a large depth of field, with a depth-independent property that is suitable for medical imaging. The limited defraction beam may be produced by a 2-D array transducer that arranges elements in a plane and can scan and focus beams electronically in any plane (page 724). The elements of such array may be grouped into annular or elliptical rings and the same electrical drive signal is applied to each beam, as explained with respect to the illustration in Fig. 1. The ring pattern is changed each time beams are steered to a new direction to compensate the effective aperture reduction of the array.

Lu mentions at page 726 that the limited defraction beams that may be scanned with such arrays include Bessel beams and X-waves, which may be produced by a multi element transducer. The steering of such beams is accomplished by using a small number of drive waveforms and apply them to a group of elements of the 2-D arrays, arranged in annular rings corresponding to annular arrays, such that linear, curve linear and sector scans are available (page 726). The number of elements required for these scans may vary, depending upon the aperture that is desired. An example of the zeroth-order Bessel beam and the drive waveforms

for such beam are provided in the results reported for the project at pages 729-732. According to Lu, with compensation for the effective aperture reduction of a 2-D array, transverse cross-sections of the beam may remain constant for all steering angles.

The Examiner refers to the illustration of a simplified system, which compensates for the effective aperture reduction of a 2-D array and uses an elliptic ring pattern for steering to a wide variety of directions (over 100 in a plus/minus 45° range), as illustrated in Fig. 11 at page 737. The system uses linear delays and groups the elements of the 2-D array into elliptic ring patterns. The illustrated system can steer both limited defraction beams and conventional beams based upon a 2-D array having M rows and N elements. There are m/2 linear time delay boards for beam steering, where the number of delay elements in each board is equal to the number of elements in a row.

One difference between the present invention and the system in Lu relates to the geometry of the transducer arrays and their control in order to provide a plurality of ultrasonic beams substantially simultaneously and the control of the position or orientation of the arrays.

As illustrated in Fig. 4 of the present application, the array of transducing elements is divided into subarrays (a-d) which combine to generate respective beams (A-D) when the subarrays are driven by a plurality of drive signals that are set to have certain amplitude and phase characteristics represented by Bessel functions, as explained at pages 14-16. The delay time setting unit 15 selects a suitable pattern from a plural delay patterns stored in the delay pattern storage unit 14 in order to steer the Bessel beam in a desired direction. Notably, as explained at page 16, line 15, the timing control unit 17 controls the drive signal generating unit 16 to generate drive signals at predetermined timings, so that each Bessel beam is steered in a desired direction, as indicated by the arrow in Fig. 5a. The signals are unique to each beam.

By contrast, Lu does not disclose the use of a plurality of sub-arrays that can transmit a plurality o of ultrasonic beams substantially simultaneously. Further, Applicant submits that the "waveform information setting means" limitation is to be interpreted in accordance with Section 112, paragraph 6, and that it is limited to different waveforms for each beam (a plurality of ultrasonic signals), while Lu requires a single or identical waveforms. On the basis of the

disclosure in Lu, it appears that a given beam is generated by a single signal, rather than a plurality of signals.

Claim Rejections - 35 U.S.C. § 103

Claims 5 and 7-9 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Lu. This rejection is traversed for at least the following reasons.

As a preliminary matter, Applicant submits that claims 5 and 7 would be patentable because of their dependence on claim 2. Also, the rejection of claim 8 is rendered moot by the cancellation of the claim.

With regard to claims 7 and 9, the Examiner observes that the only difference between the claimed invention and the prior art consists in controlling the position or orientation of the transducer array. The Examiner asserts it would have been obvious to control the position or orientation of the array in order to provide a different cross-section of the object being imaged. In this regard, Applicant notes that the only circuit structure that is illustrated in Lu appears in Fig. 11, and that figure contains no control device. Thus, Applicant respectfully submits that there is no basis for the Examiner's conclusion that any type of control would be obvious. The Examiner would be using hindsight to suggest any particular function of a control means, even if such means were inherent in the system of Lu.

Claims 1-9 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Lu (1994) in view of Hossack et al (6,179,780). This rejection is traversed for at least the following reasons.

As to claims 1, 3, 4, 6 and 8, the rejection is moot in view of the cancellation of the claims.

Claims 2, 5 and 7 clearly are distinguishable over Lu for the reasons given above. The Examiner combines Lu and Hossack for a rejection of all the claims. However, the Examiner cites Hossack et al solely for the teaching that Bessel beams may be transmitted simultaneously. The Examiner asserts that it is well known in the art to simultaneously transmit ultrasonic beams

in order to improve frame rate. Thus, the Examiner asserts it would have been obvious to simultaneously transmit the ultrasonic Bessel beams of Lu in order to improve the frame rate.

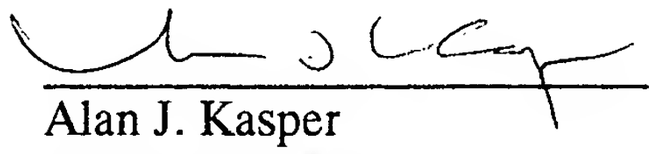
The flaw in the Examiner's analysis is that Hossack et al does not remedy the deficiencies of Lu. There is no teaching or suggestion as to how Hossack may cause a modification of Lu. Hossack does teach the use of a 2-D transducer array 12 that can be arranged on either a planar or non-planar surface. Hossack explains that the 2-D array 12 can be a fully populated array or a sparse array with a number of elements and dimensions of elements the same or different in azimuth and elevation directions. However, Applicant respectfully submits that the unique challenges posed by the use of Bessel functions and steering of the beams that result from the application of those functions to subarrays of transducers would not be solved by the general disclosure in Hossack. Applicant expressly requires in claim 7 a "control means" that controls at least one of a position of an ultrasonic transducer and an orientation of an aperture thereof, a feature not found in the prior art. Applicant respectfully submits that it would not be obvious to control the position or orientation of the arrays, as set forth in the claims, based on the teachings of the two references.

With regard to claim 9, it incorporates the limitations added to claim 2 (including the requirement for transmission "substantially simultaneously") and further specifies the use of a control means for controlling at least one position of the array and an image generating means for generating an ultrasonic image. The claim further incorporates the limitations of claim 3 and specifies that the "waveform information setting means" 13 sets the waveform information so that "said plurality of ultrasonic beams are transmitted from the same area included in said ultrasonic transducer array." Finally, Applicant again respectfully submits that it would not be obvious to use a control means that controls the position or orientation of the arrays, as already asserted with respect to claim 7.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,



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AMENDMENTS TO THE DRAWINGS

Figure 13

Attachment: Replacement Sheet